PHYTOTOXICOLOGY VEGETATION ASSESSMENT SURVEY: CORNWALL ISLAND, ONTARI0 (1993)

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Report prepared by:

R. Emerson
Standards Development Branch
Phytotoxicology Section
Ontario Ministry of Environment and Energy

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PHYTOTOXICOLOGY VEGETATION ASSESSMENT SURVEY: CORNWALL ISLAND (1993)

EXECUTIVE SUMMARY

A Federal-Provincial study with participation by several government agencies, including the Phytotoxicology Section, Ontario Ministry of Environment and Energy (MOEE), was initiated in 1975 to assess the impact of airborne fluoride emissions from the Reynolds Metals Company (RMC), Massena, New York, on the Cornwall Island Indian Reservation (Mohawks of Awkwesasne). Investigations to assess the impact of airborne fluoride emissions from RMC on vegetation on Cornwall Island have been conducted by the Phytotoxicology Section (MOEE) during the growing season annually since 1969, except for 1988 and 1990. This report presents the results of the most recent Phytotoxicology survey conducted in August 1993.

In 1993, the sampling of the regular maple foliage sites and inspections of vegetation for fluoride injury were performed only in August, similar to 1992. The highest degree of foliar contamination and most severe vegetation injury was observed in the vicinity of the south shore bridge area, similar to previous years. Fluoride concentrations in maple foliage were increased slightly in 1993 from 1992. In spite of this marginal increase, the fluoride concentration at the most contaminated Site 1(south shore bridge area) and the mean for all common Manitoba maple sites were amongst the lowest detected. In fact, foliar fluoride concentrations, on average, have fluctuated only marginally since 1978.

The rural Upper Limit of Normal (ULN) guideline for fluoride in tree foliage (15 ug/g) was exceeded at ten sites. The highest fluoride concentration (Site 1) was about ten times the rural ULN.

A few vegetation sites in 1993 had greater injury than in 1992 but, in most cases, the injury was not markedly different from 1992. Sensitive wild grape foliage in 1993 revealed no major change in the degree and extent of fluoride-type foliar injury from the previous year.

Weather conditions could have contributed to the slight increase in fluoride contamination of vegetation on Cornwall Island in 1993. RMC emissions also may have been increased but this has not been verified. Ambient fluoride monitoring on the island was not conducted by Environment Canada in 1992 and 1993.

PHYTOTOXICOLOGY VEGETATION ASSESSMENT SURVEY: CORNWALL ISLAND, ONTARIO (1993)

INTRODUCTION

Vegetation assessment surveys on Cornwall Island in Ontario, in the vicinity of the Reynolds Metals Company (RMC), Massena, New York, have been conducted by the MOEE Phytotoxicology Section during the growing season each year since 1969, with 1988 and 1990 being the only exceptions. The vegetation assessment program is part of an ongoing joint Federal-Provincial study that was established in 1975, with participation by Environment Canada, Agriculture Canada, National Health and Welfare, Indian and Northern Affairs and the Ontario Ministry of Environment and Energy. Between 1969 and 1974, the Phytotoxicology Section conducted annual vegetation surveys and investigated complaints concerning the adverse effects of airborne fluoride emissions on vegetation and cattle on Cornwall Island. The source of the fluoride emissions was identified as the Reynolds Metals Company (RMC), located in Massena, New York. RMC produces aluminum by the aluminum reduction cell process. Emissions from this process include gaseous hydrogen fluoride and particulate sodium aluminum fluorosilicate. The study was broadened in 1975 in view of the transboundary nature of the emissions and their impact on the Awkwesasne Mohawk Indian Reserve on Cornwall Island. The primary objective of the 1993 Phytotoxicology program, similar to previous years, was to determine the degree and extent of fluoride contamination and injury to vegetation on Cornwall Island and to compare these findings with previous results. The results for Phytotoxicology vegetation assessment programs through to 1992 have been previously reported.

VEGETATION ASSESSMENT PROGRAM

Visual Inspections / Samples for Chemical Analysis

In 1993, as in 1992, a single-visit survey was conducted on Cornwall Island in mid-August. Vegetation (cherry, maple, sumach, pine, wild and cultivated grape, gladiolus, vegetable crops etc.) was inspected for foliar fluoride injury at sites immediately north and northeast of RMC, as well as at more remote locations. In addition, foliage was collected from exposed middle branches at the ten Manitoba maple tree sites (1, 2, 3, 6, 7, 8, 9, 20, 21, 33), and at the three red maple sites (south shore woodlot west of bridge, south shore woodlot east of bridge, and N. Point), that were sampled in previous years. In 1993, Manitoba maple foliage also was collected for analysis adjacent to a sumach observation site near the river to the south of Maple Site 3. Duplicate samples were collected at each site using standard procedures (see attached Figure 1).

The foliage samples were returned to the Phytotoxicology Laboratory. Here, the "unwashed" samples were oven-dried, ground and stored in glass jars. All samples were then submitted to the MOEE Laboratory Services Branch for fluoride analysis. The samples of Manitoba maple foliage also were analyzed for aluminum and sodium.

Foliage Samples Collected for Laboratory Examination

Two samples were collected for histopathological examination because the injury was fluoride-like: 1) injured current-year needles from an Eastern white pine in the woodlot just east of the bridge, and 2) injured foliage from a black cherry at the Island's south shore to the west of the bridge. The samples were stored in F.A.A. preserving fluid and returned to the Section's Histopathologist.

Two samples also were collected for pathological examination: 1) honeysuckle foliage with greyish-brown upper surface injury was collected near Maple Site 21, and 2) sumach foliage with marginal and interveinal necrosis/spots, cupping and savoying was collected from a site adjacent to the river, south of Maple Site 3. These samples were submitted to the Section's Pathologist.

RESULTS OF VEGETATION ASSESSMENT PROGRAM

Visual Observations

On Cornwall Island in 1993 (August), foliar injury typical of fluoride toxicity was largely confined to the vicinity of the south shore bridge area, directly downwind and northeast of RMC. This includes residential areas in the vicinity of the Martin, A. Boots and N. Point properties (Figure 1).

In the south shore river area to the west of the bridge, fluoride-like injury on wild grape plants was light (2-10%) to moderate (11-35%) overall. The injury on wild grape plants elsewhere in the south shore bridge area was either trace (<0-1%) or trace to light (2-10%) overall. Also, in the area of the river to the west of the bridge, fluoride-like injury was observed on a young black cherry tree (light to moderate overall) and on a serviceberry shrub (trace overall). A mature black cherry in the area of the woodlot just east of the bridge also had trace injury. Fluoride-like necrosis was not observed on other cherry trees (pin, choke), or on plum trees (plot west of bridge), but as in previous years, cherry and plum foliage had missing marginal tissue symptomatic of fluoride damage.

As in previous surveys, mature staghorn sumachs in the area of the Island south shore (east and west of bridge) had varying degrees of foliar injury (marginal and/or interveinal necrosis, savoying, cupping) ranging from trace (0-1%) to severe (>35%) overall. Some sumachs to the neighbouring west of the bridge had severe injury overall, while other injured sumachs in the south shore bridge area had trace to moderate injury overall. The injury on sumach (usually considered intermediate in sensitivity to fluoride) often appeared too severe and out of context relative to the condition of neighbouring vegetation, including sensitive species (eg. wild grape, Manitoba maple, eastern white pine), to be entirely due to fluoride. In 1993, similar injury also was observed on sumach foliage more remote from RMC (near river, south of Maple Site 3). Only a few of the numerous sumachs at this site were affected. However, the pathological examination results, together with the fluoride level of the

Manitoba maple foliage (33 ug/g) collected in this area, did not implicate fluoride as the primary cause. Nevertheless, as the most severe and extensive sumach injury was observed in the south shore bridge area where foliar injury was most pronounced on other species, the possibility that RMC emissions had contributed to the injury in the south shore bridge area can not be ruled out.

Manitoba maple trees in the south shore bridge area, including Site 1, had either trace (0-1%) or trace to light (2-10%) fluoride-like foliar injury (tip or sinus necrosis) overall, with the most pronounced injury being observed on the L. Point property. However, as these and other Manitoba maple trees in the south shore bridge area had boxelder borer damage, which can result in foliar injury mimicking fluoride, Manitoba maples are not considered to be reliable indicators of fluoride exposure. Red/silver maple trees had trace brownish or blackish tip necrosis, including the red maple site in the west of bridge woodlot and the N. Point site. A few young silver maple trees on the A. Boots property also had some leaves with trace injury (blackish tips). The most severe injury was observed on red maple in the south shore woodlot just east of the bridge. At this site, brownish/blackish marginal necrosis was pronounced on several leaves, with the injury being moderate (11-35%) to severe (>35%) overall. The injured foliage had an abnormally elevated fluoride level (90 ug/g), an indication that fluoride had contributed to the injury. However, it is doubtful that fluoride was responsible for all of the injury here, as the foliar level of 90 ug/g was only marginally higher than that in the red maple foliage from the west of bridge woodlot (68 ug/g) and from the N. Point site (62 ug/g), where only traces of injury were apparent. The red maple injury also appeared too severe in relation to the injury severity on other affected deciduous species in this area (eg. gladiolus, wild grape, black cherry, Manitoba maple) to be entirely due to fluoride.

Two mature Eastern white pine in the east of bridge woodlot (behind Martin banquet hall, just west of injured red maple) had reddish tip necrosis on current-year needles throughout the crown. The histology results implicated fluoride, but other causal factors may also be involved because other white pine in this woodlot and elsewhere, including those in the west of the bridge woodlot and red and scots pines on the slightly more remote N. Point property, displayed no obvious fluoride injury on current needles. One of the injured white pine had soil piled against the trunk, and a mature maple tree had toppled onto the side of the other injured pine resulting in damaged branches. These physical factors may have contributed to the foliar injury.

The inspections in the south shore bridge area to the northeast of RMC included gladiolus plants on the Martin property, cultivated grape at A. Boots, and vegetable crops on the L. Point and N. Point properties (A. Boots did not have a garden). The gladiolus foliage on the Martin property had light injury overall, and the cultivated grape vines on the A. Boots property had some leaves with trace (0-1%) to light (2-10%) fluoride-like injury (primarily tip injury). Garden crops appeared in normal condition. Vegetation, including wild grape and garden crops, also was inspected in the vicinity of the G. Charrow property immediately north of RMC, but no obvious fluoride injury was observed on vegetation in this area.

The inspections more remote from RMC through to A. Lazore (East end of Island) revealed fluoride-like injury only on sensitive grape foliage. The wild and cultivated grape sites that were inspected to the northeast of RMC (beyond A. Boots and N. Point), including sites near the center and east end of the island (Elijah Benedict, Earny Benedict, A. Lazore), displayed either no injury or only a few leaves with inconsequential tip injury. The observations on sensitive wild grape foliage in 1993 revealed no major change in the degree and extent of fluoride-type foliar injury from the previous year.

The observations in the south shore bridge area in August 1993 are compared to the 1991 and 1992 injury ratings in Table 1. A few vegetation sites in 1993 had greater injury than in 1992 but, in most cases, the injury was not markedly different from 1992.

Analytical Results

Fluoride

The Manitoba maple fluoride results for 1993 are compared with previous survey data in Table 2. In August 1993, as in previous years, fluoride concentrations in Manitoba maple foliage were the highest at Site 1 (155 ug/g) in the south shore bridge area and sharply decreased with increasing distance from RMC. In 1993, fluoride levels were increased over 1992 levels at all but one of the ten Manitoba maple sites. However, at most sites, including Site 1, the fluoride concentration was only marginally higher than in 1992, with the level at Site 1 (155 ug/g) being amongst the lowest detected at this site. Since 1980, August fluoride levels at Site 1 have ranged from a low of 135 ug/g (1992) to a high of 389 ug/g (1984). The fluoride mean for all common Manitoba maple sites also was marginally higher in 1993 (39 ug/g) compared to the 1992 mean (31 ug/g), which was the lowest detected since 1980. Since 1980, the mean for all common sites has ranged from a low of 31 ug/g (1992) to a high of 92 ug/g (1984).

In 1993, seven of the ten Manitoba maple sites had a foliar fluoride concentration exceeding the Phytotoxicology Section Upper Limit of Normal (ULN) rural guideline of 15 ug/g. This compares to five sites in both 1991 and 1992. All three red maple sites, similar to previous years, also exceeded the rural ULN. The highest level detected in 1993 (155 ug/g - Site 1) was about ten times the rural ULN.

The three red maple sites in the vicinity of the south shore bridge area also had a slightly higher fluoride level in 1993 compared to 1992 (Table 3). The red maple at the east of bridge woodlot site (northeast of RMC) had the highest level (90 ug/g), as in previous years. Since 1982, fluoride levels in red maple foliage from the two south shore woodlots have ranged from a low of 22 ug/g (1985) to a high of 278 ug/g (1984).

Figure 2 illustrates the fluoride concentration at Site 1 from 1972 to 1993. Foliar fluoride concentrations declined abruptly in 1978. Since 1978 and up to 1993 the concentrations have fluctuated both up and down but there has not been a consistent trend

towards either an increase or a decrease in fluoride contamination at this site. In short, at Site 1, which historically has had the highest fluoride levels, there has not been an improvement in air quality since about 1978.

Aluminum and Sodium

The aluminum and sodium results for the Manitoba maple sites are compared to previous survey data in Tables 4 and 5, respectively. As with fluoride, the highest foliar concentrations of aluminum (270 ug/g) and sodium (155 ug/g) were detected at Site 1 in the south shore bridge area to the northeast of RMC.

In 1993, half the sites had higher aluminum concentrations and half had lower concentrations, compared to 1992. The common Manitoba maple sites also had a slightly lower mean in 1993 (102 ug/g) compared to 1992 (107 ug/g). Since 1980, August aluminum concentrations at Site 1 have ranged from a low of 91 ug/g (1989) to a high of 420 ug/g (1992). The mean for all common sites has ranged from 44 ug/g (1989) to 145 ug/g (1980). Similar to previous years, none of the sites exceeded the rural ULN for aluminum (500 ug/g).

Foliar sodium concentrations at most sites (7 of 10 sites) were decreased or unchanged in 1993 compared to 1992. The level at Site 1 (155 ug/g) was amongst the lowest detected since 1980. The 1993 mean (66 ug/g) of common collection sites also decreased from 1992 (74 ug/g) and was similar to the low 1987 mean (65 ug/g). As in previous years, most sites exceeded the rural ULN for sodium (50 ug/g). The sodium level at Site 1 (155 ug/g) was about three times the rural ULN.

Histopathological and Pathology Results

Results of the histopathological examination of the injured current-year Eastern white pine needles (woodlot east of bridge) and of the injured black cherry foliage (south shore west of bridge) revealed that the injury in both cases was typical of fluoride.

The pathological examination of the injured sumach foliage (south shore, south of maple Site 3) revealed that a leaf spot disease (*Phyllosticta sp.*) had contributed to the interveinal spots/necrosis on the leaves. The brownish surface scorch on honeysuckle foliage (south shore, west of bridge) was attributed to leafminer injury, but the species was not identified.

METEOROLOGICAL ASPECTS

The wind data in 1993, as in 1992, was obtained from the Airport at Massena, New York. The rainfall data was obtained from the City of Cornwall Climate station rather than from the Ontario Hydro Climate Station (west of Cornwall), which has been slow to report the rainfall data in recent years. Massena and the City of Cornwall are on opposite sides of the river across from Cornwall Island.

The wind data (Table 6) shows the percentage of time wind was blowing from the south, south southwest, southwest and west southwest during June through August in 1993, compared to 1991 and 1992. These winds are primarily responsible for carrying RMC emissions onto Cornwall Island. Table 6 shows that there was an overall slight increase in wind from these directions in 1993 (35%) compared to both 1991 (29%) and 1992 (32.5%).

Within limits, rain can also influence fluoride concentrations in vegetation. Rain can remove fluoride, especially of the particulate type, through foliar rinsing. Rain-washed foliage could be a factor in this survey because RMC emits sodium aluminum fluorosilicate as a particulate, in addition to gaseous hydrogen fluoride. This washing action can be reflected in the analytical results wherein years with high rainfall are expected to have lower fluoride concentrations if other factors are held constant. Conversely, dry years should be associated with higher fluoride values. The rainfall data (June through August) obtained from the City of Cornwall station (Table 7) shows that there was less rainfall and fewer days with rain during June through August in 1993 compared to 1992. This reduction in rainfall and the increase in south to southwest winds likely contributed to the increased fluoride concentrations in vegetation in 1993. An increase in emissions from RMC (not confirmed) also could have contributed.

Ambient fluoride monitoring on the island was not conducted by Environment Canada in 1992 or 1993. Traditionally these data have been used to corroborate Phytotoxicology data.

SUMMARY OF 1992 SURVEY FINDINGS

The main findings of the 1993 survey on Cornwall Island can be summarized as follows:

1) RMC emissions during 1993 resulted in elevated levels of fluoride, aluminum and sodium in vegetation, particularly at Site 1 in the south shore bridge area (northeast of RMC). Fluoride levels in vegetation, similar to previous years, displayed a decreasing pattern with increasing distance from RMC.

2) Fluoride levels in maple foliage increased slightly in 1993 over 1992. This was due, in part, to an increase in south and southwest winds and a slight reduction in rainfall in 1993. In spite of the slight increase in fluoride contamination, the fluoride level at Site 1 and the mean for all common Manitoba maple sites were amongst the lowest detected. The level of sodium at Site 1 and the mean for 1993 also were amongst the lowest detected.

3) The Phytotoxicology Section rural Upper limit of Normal (ULN) guideline for fluoride in tree foliage (15 ug/g) was exceeded at 10 of the 13 regular maple sites, compared to 8 sites in 1991 and 1992. The rural sodium ULN (50 ug/g) was exceeded at 7 Manitoba maple sites. Similar to previous years, the ULN for aluminum was not exceeded, although an aluminum concentration gradient relative to RMC was evident.

4) Fluoride-like injury on vegetation, as in previous years, was generally confined to the south shore bridge area of Cornwall Island. A few vegetation sites in 1993 had greater injury than in 1992 but, in most cases, the injury was not markedly different from 1992. Sensitive wild grape foliage in 1993 revealed no major change in the degree and extent of fluoride-type foliar injury from the previous year.

In conclusion, concentrations of fluoride in vegetation on Cornwall Island were increased slightly in 1993 over 1992. As in previous years, the highest degree of foliar contamination and most adverse vegetation injury were confined to the south shore bridge area to the northeast of RMC. With few exceptions, the vegetation injury in this area was not markedly different from 1992. Weather conditions could have contributed to the slight increase in fluoride contamination of vegetation on Cornwall Island in 1993. On average, the trend in foliar fluoride concentrations at Site 1 (traditionally the most contaminated site) has not changed (neither improved nor deteriorated) since 1978.

Table 1: Fluoride-like Foliar Injury Observed in Vicinity of the South Shore Bridge Area of Cornwall Island: August 1991 to 1993

Species	Foliar Injury Description	General Location	Overall Severity		
			1991	1992	1993
Black Cherry	Reddish-brown marginal and/or tip necrosis	Near River (1)	L	L-M	L-M
		Woodlot Area (2)	NR	NI	T
Pin Cherry	Reddish-tan marginal and/or tip necrosis	Woodlot Area (1)	NI-T	NI	NI
		River Area (1)	T	T	NI
		River Area (2)	T	NI	NI
Manitoba Maple	Reddish-tan marginal necrosis and/or tip or sinus necrosis	Site 21 (1)	NI	NI	NI-T
		Site 1 (2)	L-M	T	T
		Site 33 (2)	T	NI	NI-T
		L. Point (2)	T-L*	T	T-L
Red/ Silver Maple	Brownish-black marginal and/or tip necrosis	Woodlot (1)	T	T	T
		Woodlot (2)	L	T	M-S
		N. Point (2)	T	NI	NI-T
		A. Boots (2)	T	T	NI-T
Plum	Reddish-brown marginal and/or tip necrosis	L. Point (2)	T-L*	NI	NI
Serviceberry	Reddish-brown marginal and/or tip necrosis	River Area (1)	T-L	L	T
Staghorn Sumach**	Red-brown to blackish marginal-interveinal injury, savoying, cupping, broken margins	Plum Plot Area (1)	T-L*	L-M	L-S
		Woodlot Area (1)	L	L	T-S
		River Area (1)	T-L	L-S	M
		Woodlot Area (2)	NR	L	L-M
		River Area (2)	L-M	T-M	L-M
Wild Grape	Reddish-brown marginal and/or tip necrosis	Woodlot Area (1)	T-L	T-L	T-L
		River Area (1)	L	T-L	L-M
		Woodlot Area (2)	T-L	T	NI-T
		River Area (2)	T-L*	L	T
		N. Point (2)	T-L	T	T
		A. Boots Area (2)	T-L	T	T
		Customs Area (1)	T	NI-T	NI-T
Cultivated Grape	Reddish-brown marginal and/or tip necrosis	A. Boots (2)	T	T	T-L
Gladiolus	Reddish-brown marginal injury	Martin Property (2)	NP	NP	L
		N. Point (2)	T	T	NP
Eastern White Pine	Reddish-brown tip necrosis	Woodlot (2)	T	NI	L-M

* July Rating. **1992/1993 injury ratings reflect necrosis & savoying; 1991 ratings reflects necrosis. NR - Not examined. NP - No plants. (1) - Area west of Bridge. (2) - Area east of Bridge. Injury Ratings: NI - No injury; T - 0-1%; L - 2-10%; M - 11-35%; S - >35%.

Table 2: Concentrations of Fluoride in Manitoba Maple Foliage on Cornwall Island: August 1972 to 1993

Year	Concentration* of Fluoride in Unwashed Foliage										
	Sampling Location (see Figure 1)										
	Site 1	Site 33	Site 3	Site 6	Site 7	Site 21	Site 2	Site 8	Site 9	Site 20	Mean **
1972	451	NR	NR	317	90	NR	NR	30	NR	NR	NC
1973	597	NR	NR	244	NR	NR	NR	NR	NR	NR	NC
1974	516	NR	NR	98	79	NR	NR	76	NR	NR	NC
1975	1171	NR	NR	235	100	NR	NR	60	66	NR	NC
1976	550	NR	122	114	116	NR	123	29	31	NR	NC
1977	750	NR	217	56	37	NR	138	45	14	NR	NC
1978	193	NR	32	22	23	NR	17	15	7	6	39
1979	197	NR	57	32	21	NR	31	21	15	15	49
1980	143	NR	60	23	15	NR	10	8	5	3	33
1981	192	NR	86	71	64	NR	50	18	26	29	67
1982	380	NR	70	28	15	NR	25	12	18	17	71
1983	293	123	97	48	37	NR	57	27	19	31	76
1984	389	117	113	57	39	NR	63	23	14	41	92
1985	337	71	92	48	33	NR	50	32	22	26	80
1986	159	49	48	25	18	69	27	19	17	19	42
1987	149	48	59	44	24	74	48	18	14	22	47
1989	140	55	51	15	13	76	35	10	8	15	36
1991	375	78	41	29	14	93	14	7	9	15	63
1992	135	47	26	26	15	70	15	11	6	10	31
1993	155	70	40	20	21	99	37	14	12	12	39

* ug/g, dry weight, mean of duplicate (1987 to 1993) or triplicate (1975 to 1979; 1983 to 1986) samples and analysis. A single sample per site was collected from 1972 to 1974 and from 1980 to 1982.
** Mean of Common Sites, excluding Sites 21 and 33.
NR - No result, samples not collected/analysis not conducted.
NC - Mean not calculated because of fewer common sites.
Note a: Shaded values exceed Phytotoxicology Section Upper Limit of Normal (ULN) rural guideline of 15 ug/g (see appendix).
Note b: Samples have been analyzed by ion selective electrode since 1982. Alkali fusion method was used prior to 1982

Table 3: Concentrations of Fluoride in Red Maple Foliage on Cornwall Island in August: 1982 to 1993.

Year	Foliar Fluoride Concentration*		
	Woodlots at South Shore of Island		More Distant N. Point Property
	West of Bridge	East of Bridge	
1982	118	99	NR
1983	NR	NR	NR
1984	134	278	172
1985	22	139	88
1986	37	43	42
1987	59	109	81
1988	NR	NR	NR
1989	48	64	44
1990	NR	NR	NR
1991	34	195	62
1992	39	57	34
1993	68	90	62

* ug/g, dry weight, mean of triplicate (1984) or duplicate (1985-1993) samples. Single samples were collected in 1982.
NR - No results, samples not collected.
Note: Shaded values exceed Phytotoxicology Section Upper Limit of Normal rural guideline of 15 ug/g.

Table 4: Concentrations of Aluminum in Manitoba Maple Foliage on Cornwall Island: August 1980-1993

Site No.	Location**	Concentration* in Unwashed Foliage											
		1980	1981	1982	1983	1984	1985	1986	1987	1989	1991	1992	1993
1	1.5 NE	346	190	174	181	193	217	127	101	91	390	420	270
33	1.9 NE	NR	NR	NR	131	130	62	45	72	70	115	130	120
3	3.1 NE	120	101	74	99	107	84	47	62	57	66	77	65
6	4.1 NE	86	125	32	79	69	78	22	67	27	67	85	46
7	6.8 NE	314	334	70	110	103	137	41	77	35	95	100	106
21	1.3 NNE	NR	NR	NR	NR	NR	NR	29	76	45	84	165	116
2	2.0 NNE	106	146	96	128	83	90	47	185	68	75	57	88
8	1.9 N	58	68	51	96	57	115	35	67	31	73	41	111
9	2.5 N	40	52	49	66	26	58	28	58	13	35	20	65
20	6.1 ENE	96	73	80	110	81	74	27	51	35	73	57	62
Mean* **		**145**	**136**	**78**	**108**	**89**	**106**	**46**	**83**	**44**	**109**	**107**	**102**

* ug/g, dry weight, mean of duplicate (1987 to 1993) or triplicate (1983 to 1986) samples. Single samples were collected from 1980 to 1982.

** Approximate distance (meters) and direction from RMC.

*** Mean of common sites, excluding Sites 21 and 33.

NR - No results, samples not collected/analysis not conducted.

Note: Phytotoxicology Section rural ULN guideline for aluminum is 500 ug/g.

Table 5: Concentrations of Sodium in Manitoba Maple Foliage on Cornwall Island: August 1980-1993

Site No.	Location**	Concentration* in Unwashed Foliage											
		1980	1981	1982	1983	1984	1985	1986	1987	1989	1991	1992	1993
1	1.5 NE	460	202	520	373	480	420	137	105	275	325	250	155
33	1.9 NE	NR	NR	NR	253	287	160	110	81	145	120	145	99
3	3.1 NE	220	180	245	157	223	143	84	88	100	105	81	70
6	4.1 NE	123	137	112	107	109	100	65	61	40	65	78	52
7	6.8 NE	104	90	48	67	95	89	48	36	64	50	51	51
21	1.3 NNE	NR	NR	NR	NR	NR	NR	117	99	205	180	140	125
2	2.0 NNE	80	93	132	70	85	81	69	91	73	59	27	54
8	1.9 N	90	70	85	77	68	64	39	57	70	66	34	56
9	2.5 N	75	73	125	43	61	34	35	36	23	36	19	42
20	6.1 ENE	77	90	53	77	99	105	74	52	58	56	56	44
Mean* **		**153**	**116**	**165**	**121**	**152**	**129**	**68**	**65**	**87**	**95**	**74**	**66**

* ug/g, dry weight, mean of duplicate (1987 to 1993) or triplicate (1983 to 1986) samples and analysis. A single sample per site was collected from 1980 to 1982.

** Approximate distance (meters) and direction from RMC.

*** Mean of common sites, excluding Sites 21 and 33.

NR - No result, samples not collected/analysis not conducted

Note: Shaded values exceed Phytotoxicology Section rural ULN guideline for sodium of 50 ug/g.

Table 6: Percentage (%) of Time Wind was Blowing from South and Southwest Directions at Massena Airport during June to August, 1991 to 1993.

Direction	1991	1992	1993
South	*0.8*	*1.1*	*2.3*
South Southwest	*1.3*	*2.3*	*3.2*
Southwest	*6.4*	*6.2*	*8.6*
West Southwest	*20.5*	*22.9*	*20.9*
Total	***29***	***32.5***	***35***

* From June through to and including date of foliage collection: 1991 - Aug. 22;
1992 and 1993 - Aug. 11.

Table 7: Total Precipitation (mm) and Number of Days (Frequency) with Rain, City of Cornwall: June through August, 1992 and 1993.

Month	1992		1993		Normals**	
	Total Rain	Frequency	Total Rain	Frequency	Total Rain	Frequency
June	*73*	*13*	*113*	*14*	*81.8*	*11*
July	*117*	*15*	*82*	*11*	*84.3*	*10*
August*	*40*	*6*	*19*	*7*	*97****	*11****
Total	***230 (7)***	***34***	***214 (8)***	***32***	***NA***	***NA***

* Through to and including date of regular maple foliage collection (August 11)
** Rainfall normals taken from Canadian Climate Normals (1961-1990), Atmospheric Environment Service, Environment Canada, Toronto.
*** All of August
( ) Number of days with rain during two week period prior to and including date of foliage collection.
NA Not available.

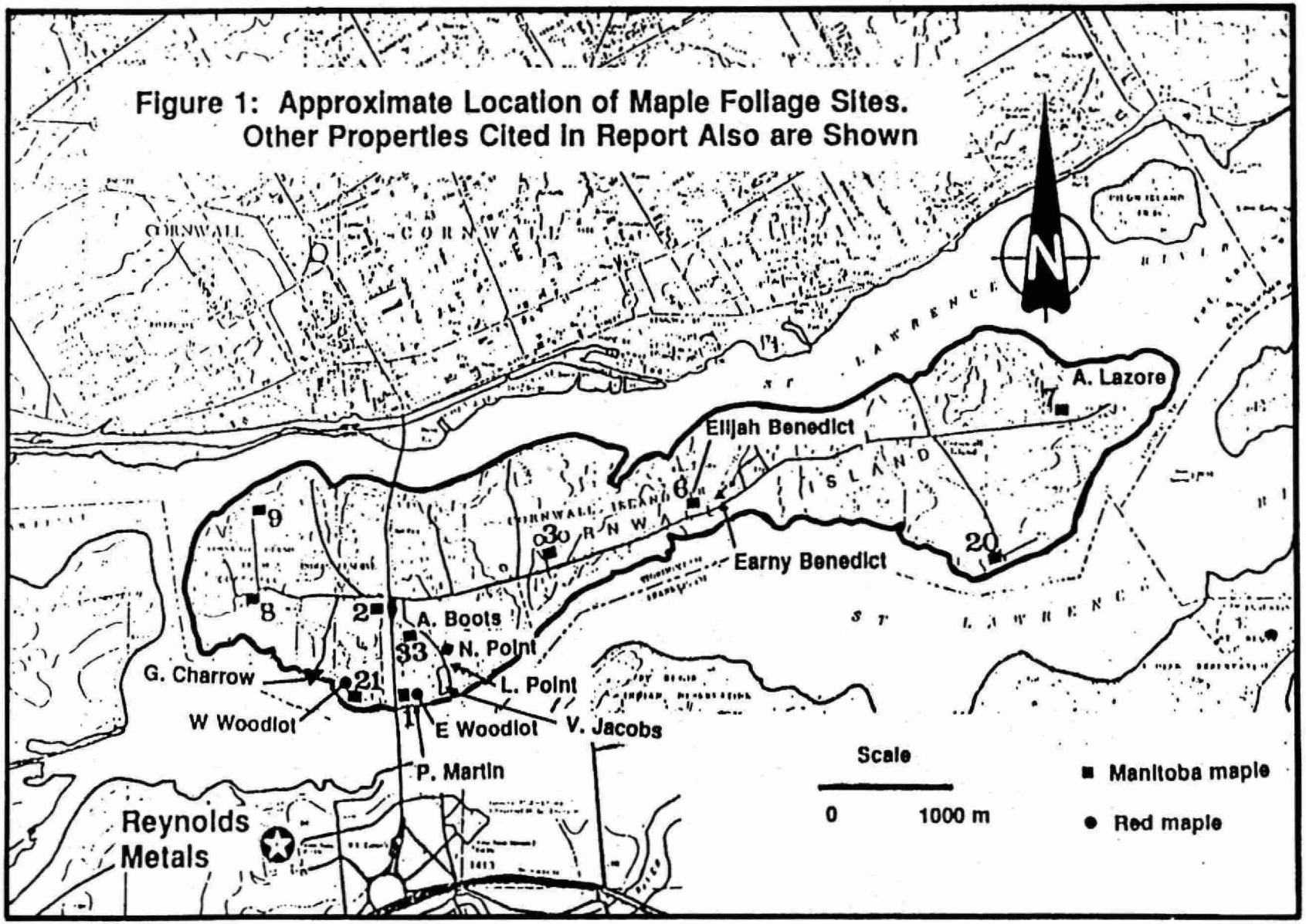
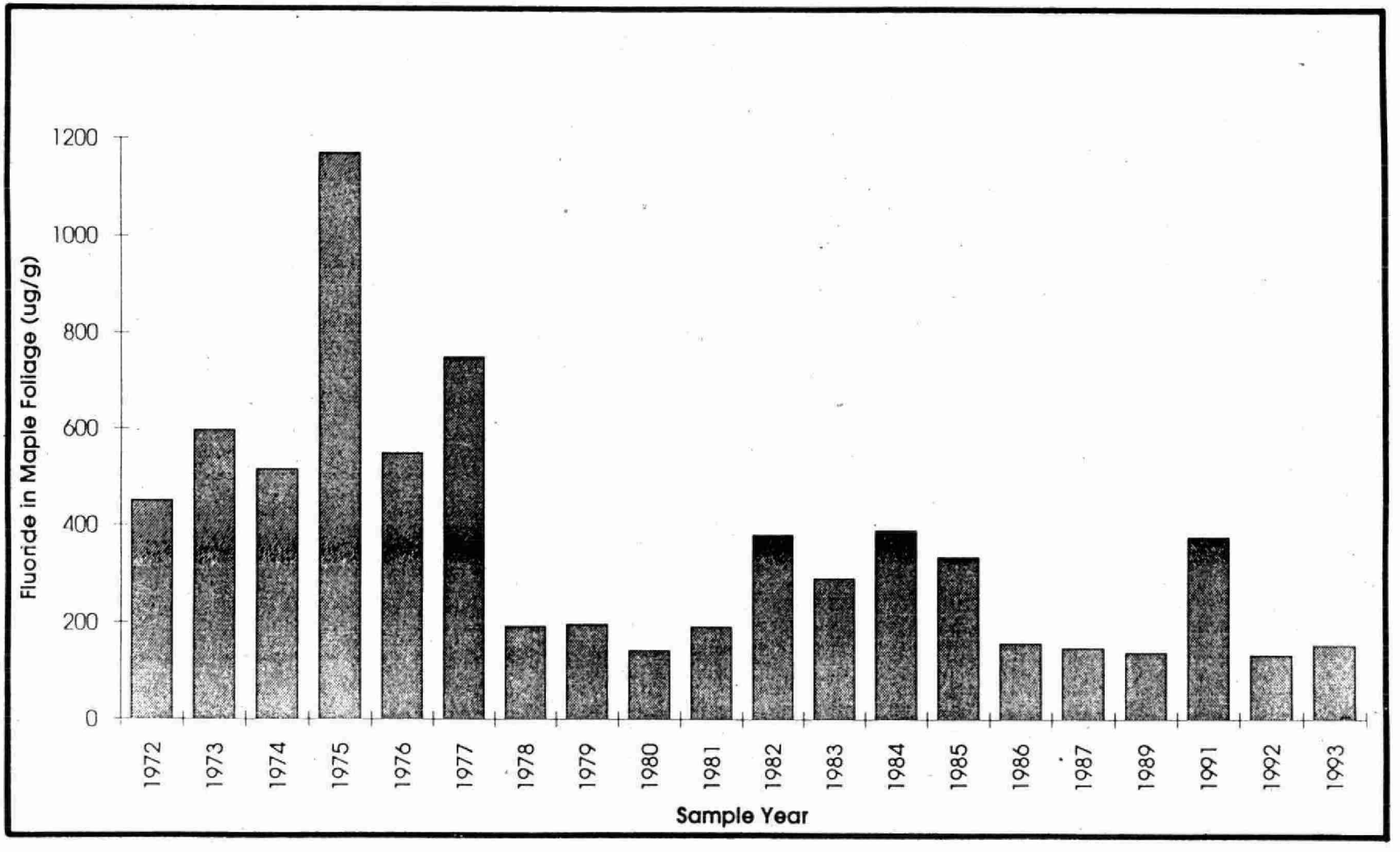


Figure 1: Approximate Location of Maple Foliage Sites.
Other Properties Cited In Report Also are Shown
CORNWALL
CORNWALL ISLAND
ST LAWRENCE
A. Lazore
Elijah Benedict
Earny Benedict
A. Boots
N. Point
L. Point
V. Jacobs
E Woodlot
W Woodlot
G. Charrow
P. Martin
Reynolds Metals
9
8
2
33
21
1
3
6
20
Scale
0
1000 m
Manitoba maple
Red maple

Figure 2: Foliar Flouride Concentration at Manitoba Maple Site 1 in August: 1972 through 1993.



Appendix

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

AGBT